LAKE MOPATCONG MANAGEMENT/RESTORATION STUDY
EXECUTIVE SUMMARY

Lake Hopatcong is New Jersey's largest and most heavily utilized inland freshwater recreational resource for boating, swining, fishing and water skiing. Its contribution to the economy of North Central New Jersey is immense However, over the past 30 years there has been a significant decline in the water quality of the lake. The visible symptoms of this decline include massive algal blooms, excessive aquatic weed growth, depletion of oxygen in the deep waters (hypolimnion) of the lake, the accumulation of organic sediments, accumulation of heavy metals in the sediments and a general degradation of the fishery.

In recognition of the importance and problems of this resource the Lake Hopatcong Regional Planning Board (LHRPB) was created, pursuant to Article 10 of New Jersey's New Land Use Law, to develop measures to address the problems of Lake Hopatcong. The LHRPB initially conducted two studies and prepared a master plan for the basin; however, these studies did not fully address the issue of water quality. Through the 1970's with some help from the Sussex County 208 Planning Agency the LHRPB maintained a monitoring program, which did not fully quantify the sources of pollution to the lake. From 1979 to 1983 the Upper Musconetcong Sewerage Authority (MSA) and Jefferson Township completed Step I 201 Facilities Plans for all of the Lake Hopatcong basin except for Mt. Arlington. These studies documented the need for sewerage around the lake, focusing on the topic of wastewater disposal. Equally important issues of stormwater quality and management and restoration of the lake were not covered by these previous' efforts.

Recognizing the need for a comprehensive watershed and lake management plan the LHRPB obtained a grant from EPA through the New Jersey Department of Environmental Protection under Section 314 of the Clean Water Act. The objectives of this study were:

1. To identify and document water quality problems with Lake Hopatcong and to localize and quantify pollutant inputs.

2. To determine the current trophic status (degree of eutrophication, or aging) and lfmnological characteristics of the lake.

3. To develop a comprehensive basin-wide watershed management plan to reduce pollutant inputs to the lake.

4. To develop an in-lake restoration and management plan.

The study was begun in August of 1981 and completed in October of 1983.

CHARACTERISTICS OF LAKE HOPATCONG AND ITS WATERSHED

Lake Hopatcong is located in north-central New Jersey on the border between Sussex and Morris Counties. The lake covers 1087 ha (2686 acres), has a maximum depth of 17.7 m and an average depth of 5.5 m. It has 62.75 km (39 miles) of highly convoluted shoreline that forms many shallow inlets, bays and coves (Figure 1). The watershed covers 5480 ha (13,500 acres) of hilly New Jersey highlands. The watershed is underlain by Precambrian metamorphic rock covered by sporadic glacial deposits. The major soil association is the Rockaway-Rock Outcrop-Whitman Association that tends to be acidic and is classified as being moderate to severe for septic tank absorption fields.

Seventy percent of the watershed is undeveloped forest and the other thirty percent, in the immediate vicinity of the lake, is covered with high and low density residential and commercial development.

Lake Hopatcong originally consisted of two bodies of water connected by a branch of the Musconetcong River. The lake as we know it today was created in 1827 by the construction of an 11 foot dam to create a reservoir for the Morris Canal. The dam increased the water area by 452, resulting in much of the lake being extremely shallow; 11 feet or less in depth.

The major tributaries to the lake, Weldon Brook and Beaver Brook, drain approximately 5100 acres of forested watershed. These streams empty directly into Lake Shawnee (Figure 1) upstream of Lake Hopatcong, which in turn empties into Lake Hopatcong. The remainder of the watershed is drained by minor tributaries and immediate drainage to the lake.

THE PROBLEMS

Lake Hopatcong shows symptoms of advanced accelerated eutrophication. Eutrophication, the process of lake aging, is caused by excessive nutrient loadings and is characterized by algae growth and aquatic weeds. A lake's eutrophic state is most normally quantified by measuring the presence of chlorophyll a, as expressed in milligrams per cubic meter (mg m^{-3}).

During the course of this study, at the surface of the lake, maximum chlorophyll a concentrations ranged from 15.6 mg m^{-3} at mid-lake to a high of 64 mg m^{-3} in Woodport bay. These levels are well in excess of desirable levels. For comparison, 'the range of chlorophyll a values for commonly defined trophic levels are as follows:

Trophic Level Definition in Lakes

Trophic Classification	Chlorophyll a - mg m^{-3}
Oligotrophic (lowest nutrient levels)	less than 2.0
Mesotrophic (transition)	2.0-6.0
Eutrophic (excessive nutrients)	greater than 6.0

Source: USEPA Clean Lakes Program Guidance Manual

Chlorophyll a measures only planktonic algae standing crop. In addition to plankton, algae mats consisting primarily of the course filamentous blue-green algae (Lyngbya latissima) grow in the shallow coves and bays. In the summer, gasses accumulate under the mats causing them to float to the surface. These mats interfere with the recreational use of the lake and form an unsightly mass.

The occurrence of nuisance proportions of rooted aquatic plants in the shallow tone of the lake interfere with swimming and boating. The major nuisance species are Myriophyllum spicatum, Potamogeton amplifolius, Potamogeton crispus and Vallisneria americana. The low-growing Najas sp. is found in dense stands in the lake. Since it does not reach the surface, however, it generally does not interfere with surface recreational activities. The lake is treated each year with herbicides in an attempt to control these aquatic weeds.

Another symptom of eutrophication is the occurrence of oxygen depletion at the greater depths of the lake. Lpke Hopatcong undergoes thermal stratification in the summer - according to the classical pattern found in most standing water bodies. During the summer, the organic matter produced in the lake settles down into the lower depths and decays, thereby depleting the oxygen in the deep water. Since the lake is thermally, and therefore, density stratified, the deep waters do not circulate to the surface where they can be oxygenated. In Lake Hopatcong, the oxygen demand due to primary production causes the lowest layer of the lake (hypolimnion) to become anoxic by the beginning of July (Figures 8 and 9). In fact, the oxygen demand is so great that the anoxic conditions gradually move upward toward the surface. This means that the environment for cold water fish is destroyed and viable reproducing populations are difficult to maintain.

Another side effect of oxygen depletion is that it creates conditions conducive to the recycling of phosphorus. Under most conditions phosphorus would be the nutrient that limits the production and growth of vegetation. In Lake Hopatcong, phosphorus in the sediments that would normally not be available for primary production is circulated upward where it can support more vegetation production and exacerbate the algae problem.

Due to the high primary production of vegetation in the lake there is incomplete degradation of organic matter and the excess accumulates as thick mucky sediment. This sediment characteristically has low redox potentials that also favor the recycling of phosphorus from the sediments into the water column.

Other problems in the lake involve the accumulation of heavy metals in the sediments and erosion of silt and sediment into the lake. Thirty sediment core samples were taken from several locations in the lake. These were analyzed for heavy metals. The surficial sediments, at the sediment-water interface had as high as 1220 mg kg^{-1} dry weight lead and 10 mg kg^{-1} dry weight cadmium. Sediment samples show that high sediment metal concentration are of recent origin.

CAUSES OF THE PROBLEMS

Excess nutrient inputs which support weed and algae growth are the primary cause of Lake Hopatcong's eutrophication problems. Ttie element phosphorus is the main problem. The total external phosphorus load to Lake Hopatcong was estimated at 3655 kg yr^{-1} or 0.34 g m^{-2} yr^{-1} and with internal recycling the load is 4249 kg yr^{-1} or 0.39 g m^{-2} yr^{-1}. This is a substantial load and places the loading rate for Lake Hopatcong in the eutrophic range (Tables 49 and 51).

The story of Lake Hopatcong is similar to that of many lakes in the northeastern United States. Initially, many summer homes and resort hotels were built on the lakeshore. However, with improved transportation routes and the increased cost of maintaining two residences many of these seasonal homes were converted to year-round dwellings and along with the building boom of the 60's and 70's the area in the immediate vicinity of the lake became urbanized. Unfortunately, this development took place without adequate consideration of the impacts of the development on the lake.

All homes on Lake Hopatcong have on-site waste disposal systems. Many of these systems were sized for seasonal use only and never enlarged. Many are located in soils that-have severe limitations for septic leach fields. In the development process, little consideration was given to stormwater control. To illustrate how development can affect the phosphorus load; if the basin had remained undeveloped, the phosphorus load to the lake would be approximately 1200 kg/yr or 0.11 g m^{-2} yr^{-1}. This is substantially below the permissible or oligotrophic loading rate of 0.17 g m^{-2} yr^{-1}. Figure 23 illustrates the trophic state of Lake Hopatcong with and without development.

The aquatic weed and benthic algae problem is further exacerbated by the physical dimensions of the lake. Approximately 45% of the lake area is 10 feet deep or less, and there is a large expanse of shoreline (39 miles). The combination of these two factors creates an extremely large shallow area where light can penetrate to the bottom with sufficient intensity and quality to support photosynthesis and consequently rooted weed and benthic algae growth. The erosion of sediment into the shoreline areas and the deposition of nutrient-rich internally produced organic sediment creates optimum conditions for aquatic plant and benthic algae growth.

The vast littoral area with its potential for primary production could, in itself, produce enough organic matter to cause oxygen depletion in the depths of the lake.

The accumulation of metals in lake sediments especially lead, can be attributed to the use of leaded gasolines in automobile and boat engines. The pathways of lead to the lake sediments include stormwater runoff from the streets; dry and wet deposition from the atmosphere; and the use of leaded gasoline in outboard motors. The highest concentrations of metals were found in restricted coves that received substantial stormwater runoff from residential streets (Landing and Crescent Cove). The change-over to unleaded gasoline in automobiles will substantially reduce this problem in the future. Through Extraction Procedure Toxicity Leachate Analysis (EP Toxicity) it was determined, however, that the metals do not leach into the water column. Analysis of fish tissues showed no appreciable bioaccumulation of metals.

A PLAN TO RESTORE AND MANAGE LAKE HOPATCONG

Evaluation of Lake Hopatcong's status, its problems and their causes was done to develop a plan to *restore* the quality of the lake and to preserve the lake's value as a major regional recreational resource. The plan recognized that most of Lake Hopatcong's problems with water quality degradation arise from the. intense development that occurred along the shoreline of the lake without proper planning for wastsewater treatment and stormwater control. The plan also recognized that major changes need to be made with regard to this development, changes that require many years in order to be implemented.

The Lake Hopatcong Management and Restoration Plan presents recommendations that have both long range and more immediate impacts. The long range measures deal primarily with the causes of lake degradation; the more immediate measures are designed to treat the principal symptoms of degradation now being experienced.

Long Range Measures

1. Most of the basin (except Mt. Arlington) has been the subject of recent Sec. 201 Wastewater Facility Plans. The Jefferson Township plan recommended sewering the portion of that township located in the Hopatcong Basin. The Musconetcong Sewerage Authority's Facility Plan should result in sewering parts of the Borough of Hopatcong, Roxbury, and Landing. The Lake Hopatcong Management Plan recommends that these projects be implemented for their substantial positive impacts on water quality in Lake Hopatcong.

2. The Plan recommends that the municipalities of the watershed delegate to the Lake Hopatcong Regional Planning board the authority for stormwater management planning and implementation under NJAC 7:8. This would allow for development of an integrated basin-wide stormwater management program. New concepts in stormwater management can be implemented that would substantially reduce pollutant loads to the lake.

3. The Liffy Island area of the lake should be acquired by Jefferson Township to maintain this area as a natural park to protect it from future development, to preserve it as an aesthetic resource for all of the lake users, and to protect the fish spawning areas in the vicinity of the island.

4. Implement a public education program to inform citizens of the best management practices that they can implement individually and to develop support for the overall lake restoration program.

The long range measures proposed by the plan will take many years to accomplish, at a cost of millions of dollars. The short-term measures proposed are designed to maintain the lake in a usable condition during the period of implementation.

Short Term Measures

1. Aquatic Weed Harvesting. Heed control by chemicals do more to harm lake quality in the long run than to restore it in the short run. Therefore, it is recommended that aquatic weeds be harvested in order to remove nutrients and biomass from the lake.

2. Lake Drawdown. By coupling aquatic weed harvesting with controlled lake drawdown in the winter to expose the aquatic weeds, the weeds will be controlled in an ecologically sound manner and the lake sediments will be consolidated. Such action should significantly improve water quality and decrease internal nutrient loading.

3. Dredging. Some dredging is proposed in localized areas ot he lake where there is heavy deposition of silt.

4. Continued Monitoring. Lake monitoring programs should continue as a necessary means of identifying continued short-term improvement measures and documenting the impacts of both short-term and long range restoration measures.

IMPLEMENTING THE PLAN

A comprehensive, basin-wide plan to integrate a number of water resources programs has been developed. The plan is designed to provide comprehensive watershed management to reduce pollutant inputs to the lake, and to restore water quality through an in-lake restoration program. To implement the plan the following are required:

1. Adequate funding from several sources.

2. A single, basin-wide management organization.

It is proposed that the Lake Hopatcong Regional Planning Board expand its authority as a regional management organization and pursue legislation that will permit it to develop funds through nominal taxing power, user fees and grants. It is expected that necessary sewerage improvements will be made through existing local, state and federal funding sources related to EPA's Section 201 sewerage construction grant program.

The effort described in this report, funded by EPA's Clean Lakes Program, has provided a tremendous opportunity to those concerned with Lake Hopatcong's future and its value as a regional resource. The Lake Hopatcong Regional Planning Board serves as a focal point for public involvement and public awareness with regard to the deteriorating quality of the lake, and the means of restoring the lake. The proposed management plan, when enacted, will not only improve the quality of lake waters, but will help to maintain property values, the economic and recreational value of the basin, and the overall quality of life that prompted the original development of the Lake Hopatcong watershed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

SECTION I

INTRODUCTION

A. HISTORY AND PURPOSE OF PHASE I DIAGNOSTIC-FEASIBILITY STUDY

The degradation of water quality and aesthetics of many of America's freshwater lakes and ponds spurred the conception and enactment of the Federal Water Pollution Control Act amendments of 1972 (P.L. 92-500), and of 1977 (P.L. 95-217). Both are collectively referred to as the Clean Water Act. Section 314 of the Clean Water Act authorizes the protection and restoration of publicly owned water bodies by communities through the use of State and Federal funding.

Lake eutrophication is a natural process which normally occurs slowly over thousands of years. The ontogeny of a lake is such that it proceeds from a low-productive state to an overly enriched, highly productive condition. Typically young lakes are clear, support a meager phytoplankton standing crop and a low density of aquatic macrophytes. Such lakes are termed oligotrophic. As the lake ages, its physical-chemical properties change as a result of watershed erosion and the transport of nutrients and sediments into the lake. The lake becomes increasingly productive, supports a higher density of phytoplankton and aquatic macrophytes, and begins to accumulate organic sediments. Very. gradually the lake begins to fill in as these organic deposits accumulate and the aquatic macrophytes become increasingly established. Eventually the lake acquires a marshy or swampy characteristic. In time, the lake becomes completely filled and, in essence, the lake is considered "dead."

Although the ecological succession of a lake is a natural process, it can be greatly accelerated by human activities. Termed "cultural eutrophication," this speeding up of a lake's aging process is caused by increases in the amount and rate of nutrient and sediment exported by the watershed to the lake. Watershed urbanization, the discharge of insufficiently treated sewage, septic tank leakage, inadequate stormwater management, soil erosion, and the application of fertilizers all increase the nutrient load entering a water body. Increased nutrient loads stimulate' productivity, and lead to the accelerated eutrophication of the lake.

The fact that a lake is eutrophic is realized when taste and odor problems, algal blooms, nuisance growths of aquatic plants, oxygen depletion, the accumulation of organic sediments and fish kills are observed. These symptoms indicate that the lake is overly productive. The changes in water quality associated with such symptoms may be sufficient to transform the lake from an important community asset, to an objectionable deficit. Many of these symptoms have been observed in Lake Hopatcong. They indicate a deterioration of the lake‘s water quality and signal the necessity to curtail further lake degradation through the initiation of sound lake restoration and watershed management practices. The first step in realizing this goal is supplied by the data and conclusions of this diagnostic study.

B. OBJECTIVES OF LAKE HOPATCONG STUDY

The following study conducted by Princeton Aqua Science (PAS) for the Lake Hopatcong Regional Planning Board (LHRPB) provides the data necessary to develop a comprehensive action plan for the effective restoration and management of Lake Hopatcong.

The objectives of this study were:

A. Compile and consolidate all of the historical data and studies of the lake.

B. Conduct a comprehensive limnological evaluation of the physical, chemical, and biological characteristics of the lake. Determine the actual trophic status of the lake and elucidate its major ecological relationships.

C. Gather all of the necessary information concerning the lake to address Appendix A of 40 CFR Part 35.1600, the specific statutes of the State of New Jersey, and the regulations outlined in NJAC 7:9-15.1 *et* seq.

D. In cooperation with the Lake Hopatcong Regional Planning Board (LHRPB) develop a comprehensive watershed management and lake restoration plan for Lake Hopatcong using best management practices (BMP), in lake restoration techniques, and stormwater management methods.

SECTION II

IDENTIFICATION OF LAKE HOPATCONG

A. LOCATION OF LAKE

Lake Hopatcong, New Jersey's largest inland lake, is located on the border of Sussex County and Morris County, New Jersey. The center of the lake is at $40^{o}56'17''$ x $74^{o}38'40''$.

To the north, the lake abuts Jefferson Township, and to the south, Roxbury Township. To the east the lake is bordered by Jefferson Township, Roxbury Township and Mt. Arlington Borough and to the west by Hopatcong Borough (Figure 1).

B. MDRPHOMETRY OF LAKE

The morphometry and bathymetry of Lake Hopatcong were determined from USGS 7.5' Topographic Contour Maps, continuous recording fathometer readings, and calibrated sounding line measurements (Figures 1 and 2).

Lake Hopatcong has a total surface area of 1087 hectares (ha), a mean depth of 5.5 meters (m) and a maximum depth of 17.7 m (Table 1). Total inflow to the lake is 39.69 x $10^6 m^3 yr^{-1}$, while total outflow is 39.69 x $10^6 m^3 yr^{-1}$. The major tributaries to the lake are Beaver Brook and Weldon Brook, both of which flow into Lake Shawnee upstream of Lake Hopatcong. The maximum volume of Lake Hopatcong is 5.56 x $10^7 m^3$. Based on measured outflow and lake volume, the lake's hydraulic retention time is 623 days. This indicates that total volumetric water exchange occurs only once every 1.7 years. Discharge from Lake Hopatcong is regulated by a spillway located at Hopatcong State Park, Landing, N.J. Outflow is to the Musconetcong River, a tributary to the Delaware River.

Lake Hopatcong is a sprawling, irregularly shaped lake. It is composed of a number of shallow coves which eminate from the main body of the lake. Located in the extreme north end of the lake is Woodport Bay, a 156 ha shallow water ($\bar{x}$ depth 1.5 m) embayment. Flow from this large bay into the main lake is through a narrow passage. This impairs the flushing of Woodport Bay, and contributes to its physical, chemical, and biological features which are at times quite different than those observed in the remainder of Lake Hopatcong.

Along the western shore there are three large coves: Henderson Cove, Byram Cove, and Crescent Cove. Water depth in Henderson and Crescent Coves is typically less than 2.0 meters. Byram Cove is somewhat deeper with average water depth in excess of 2.5 meters. Outflow from Byram

Table 1

CHARACTERISTICS OF LAKE HOPATCONG, NEW JERSEY AND THE ATTENDANT WATERSHED

Official Name	Lake Hopatcong
Location	Morris and Sussex Counties, New Jersey 40°56'17" x 74°38'40"
Area	1087 ha
Average Depth	5.49 m
Maximum Depth	17.7 m
Volume	$5.56 \times 10^7 m^3$
Watershed Area	5482.7 ha
Watershed Area/Lake Area	5.0/1
Shore Line Development (D_L)	5.41
Shore Line Length	50,976 m
Hydraulic Retention Time	623 days; 1.71 yr.

Cove and Henderson Cove is fairly unrestricted. In contrast, outflow from Crescent Cove to the main basin of the lake is somewhat restricted primarily as a result of its long, narrow shape (Figure 1).

There are three major coves on the eastern shore: Great Cove, Van Every Cove, and King Cove. Water exchange between the main basin and the coves along the eastern shore is fairly free. Great Cove and Van Every Cove are comparatively deeper than the other coves of the lake. Their banks are relatively steep and depths of greater than 2.5 meters are fairly common. At the southern end of the lake there exists a shallow, narrow cove referred to in this report as Landing Channel. Outflow from Landing Channel is restricted primarily due to its long, narrow configuration, and the small amount of inflow to this embayment.

The main basin of the lake has depths ranging from 6 meters to a maximum of 17.7 meters. The main basin extends essentially from Bertrand Island north to Halsey and Raccoon Islands (Figure 2).

C. MAJOR TRIBUTARIES OF LAKE HOPATCONG

As previously mentioned, Beaver Brook and Weldon Brook are the primary tributaries of Lake Hopatcong. Other notable tributaries are Jaynes Brook and Mountain Brook, both of which discharge into Henderson Cove. There are a number of small unnamed tributaries which feed the lake. Some of these smaller tributaries are intermittent or of very low flow in the summer.

D. CLASSIFICATION OF WATERS OF LAKE HOPATCONG AND ITS TRIBUTARIES

FW-1 waters, because of their clarity, color, scenic setting, and other characteristics of aesthetic value or unique special interest have been designated by NJOEP to be set aside for posterity to represent the natural aquatic environment and its associated bfota (N.J.A.C. 7:9-4.6). These waters shall be maintained as to qualify in their natural state and shall not be subject to any manmade wastewater discharges.

FW-2 waters according to N.J.A.C. 7:9-4.6 shall be suitable for public potable water supply after such treatment as shall be required by law or regulations. These waters shall also be suitable for the maintenance, migration, and propogation of the natural and established biota; primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

Lake Hopatcong and its tributaries are classified as FW-2 Trout Maintenance waters. The lake is also designated as a potable water supply (N.J.A.C. 7:9-4).

SECTION III

DESCRIPTION OF WATERSHED OF LAKE HOPATCONG

A. GENERAL DESCRIPTION OF WATERSHED

Lake Hopatcong's watershed encompasses a total area of 5482.7 hectares (ha) exclusive of the lake's surface area. The ratio of watershed surface area to lake surface area is 5:1. Approximately 59% of the watershed is in Jefferson Township, while 20% is in Hopatcong, 11% in Sparta, 5% in Mt. Arlington and 5% in Roxbury. All except Sparta have shoreline on the lake.

To the east and west of Lake Hopatcong the topography rises abruptly from the lake and forms a series of ridges which parallel the lake's shoreline. The ridgelines delineate the eastern and western boundaries of the watershed. Contained within the eastern part of the watershed are sections of Jefferson Township, Roxbury Township, and Mount Arlington Borough. The western watershed envelops much of Hopatcong Borough. To the north the watershed extends to the Bowling Green Mountain ridgeline. The northwestern fringe of the watershed encompasses a section of Sparta Township.

B. GEOLOGY

The Lake' Hopatcong watershed is located in the New Jersey Highland physiographic province, which is a portion of the Reading Prong of the New England Province. This is the oldest and most resistant rock formation in Morris and Sussex Counties. The watershed is characteristically underlain by' hard, crystalline, resistant, Precambrian igneous and metamorphic rocks (Lucey, 1975). The paragneisses tend to be well foliated, well layered, and consist chiefly of biotite-feldspar- quartz gneisses and quartz-oligoclase leucogneisses (Young, 1971). In general, the character of rock in this area can be interpreted as highly metamorphosed marble, granite, and gneiss.

Lake Hopatcong valley is developed along a series of northeast trending fault blocks. Numerous flat top ridges occur throughout the area. Along most of Lake Hopatcong's perimeter, the land rises abruptly, lending a steep slope to most of the immediate topography. The lake's valley is bounded by two ridges which are orientated northeast to southwest, parallel to the fault blocks. The maximum elevations of these ridge tops are approximately 300 to 365 m above mean sea level (MSL). The elevation of the lake itself is approximately 185 m above MSL.

C. SOILS

The entire watershed was subject to relatively recent Pleistocene Epoch, Wisconsin stage glaciation. Sporatical ly overl aying the Precambrian bedrock is stratified glacial drift or till composed of clayey material with intermingled sand, gravel, rock fragments, and boulders. The soil textures thus tend to be variable; and depending on their location in the watershed, range from muck, to sandy loams, to gravelly, to stony loams (SCS, 1975). Soil depths range from 3 m or greater above bedrock, to zero to a few cm along the rock outcrop areas. The major soils of the basin are as follows:

Southern end of watershed: Rockaway stony sandy loam/Hibernia stony loam
Southeastern side of watershed: Rockaway stony sandy loam
Southwestern side of watershed: Rockaway stony loam/Rockaway-rock outcrop
Northwestern side of watershed: Rockaway-rock outcrop
Northeastern side of watershed: Rockaway stony sandy loam/Rockaway-rock outcrop
Northern end of watershed: Rockaway complex/Whitman stony loam

The major soil association is the Rockaway-Rock Outcrop-Whitman Association. These soils tend to be acidic. The U.S. Soil Conservation Service (1975) has defined these soils in terms of composition, permeability, and steepness of slope (Table 2). These soils occur mainly on ridge tops and side slopes, and Rockaway soils account for approximately 45% of the total composition of the association. The Rockaway soils are coarse textured, well drained, and dominately steep to very steep. They characteristically have gravelly loam or very stony loam surface layers. Rock outcrops may be totally exposed or covered by a thin soil layer. They are representative of areas where 20-90% of the surface is covered by granitic rock. Whitman soils are very poorly drained, they are formed from granitic and gneissic derived material, and are underlain by a shallow fragipan. Overall, this soil association tends to.restrict development due to its shallow depth, limited permeability, and usually steep slopes (Tables 3, 4, 5, and 6) (Sussex County - 208 Agency, 1979).

Table 3

SOILS WITH DEVELOPMENT LIMITATIONS DUE TO SHALLOW DEPTH TO BEDROCK

Sussex County Soils

Shallow Depth to Bedrock -

	Slope
Na C - Nassau rocky silt loam	8 to 15%
Nf D - Nassau-Rock outcrop complex	15 to 25%
Ng - Nassau-Rock outcrop complex	extremely stony
Om B - Oquaga ● xtranely stony loam	3 to 8%
Om D - Oquaga extremely stony loam .	'8 to 25%
Or D - Oquaga-Rock outcrop association,	moderately steep
Wm D - Wassaic silt loam	15 to 30%
Wn D - Wassaic-Rock outcrop association, (extremely stony),	moderately steep

Morris County Soils

Shallow Depth to Bedrock

None

Source: Sussex County, NJ. 208 Water Quality Management Plan, 1979.

Table 4

SOILS WITH DEVELOPMENT LIMITATIONS DUE TO INTERMEDIATE OR STEEP SLOPE

SUSSEX COUNTY

Intermediate Slopes (15 - 25%) -

	Slopes
Bf D - Bath gravelly loam	1s to 25%
Bg D - Bath very stony loam	8 to 25%
Ch D - Chenango gravelly fine sandy loam	8 to 25%
Cl D - Chenango cobbly sandy loam	15 to 35%
Hf D - Hazen gravelly loam	8 to 25%
Ho D - Hoosic gravelly loam	8 to 25%
Dt C - Dtisville gravelly loamy sand	15 to 35%
Pa D - Palmyra gravelly fine sandy loam	8 to 25%
Ro D - Rockaway gravelly loam	15 to 25%
Rp D - Rockaway very stony loam	5 to 25%
Sw D - Swartswood gravelly loam	15 to 25%
Sx D - Swartswood-Lackawanna very stony soils	8 to 25%
Va D - Valois shaly loam	1s to 25%
Wh D - Washington loam	15 to 25%
Wk D - Washington very stony loam	15 to 25%
Wl D - Washington-Wassaic complex	15 to 252
Ws D - Wooster loam	15 to 25%

Steep Slopes (25%+)
(together with areas of extensive Rock Outcropping)

	Slopes
If E - Bath gravelly loam	25 to 40%
g E - Bath very stony loam	25 to 40%
lg E - Hazen-Palmyra gravelly sandy loams	2s to 45%
If E - Nassau-Rock outcrop complex	25 to 45%
p E - Rockaway very stony loam	25 to 40%
r 0 - Rockauav-Rock outcrop association	sloping and moderately steep
s F - Rock outcrop - Nassau association	very steep
t E - Rock outcrop - Oquaga association	steep
v E - Rock outcrop - Rockaway association	steep
x E - Swartswood-Lackawanna very stony soil	25 to 35%
Is E - Wooster loam	25 to 35%

MORRIS COUNTY

Intermediate Slopes

Dt D - Otisville gravelly loamy sand	15 to 25%
Rr D - Rockaway extremely stony sandy loam	15 to 25%

Steep Slopes; (25%+)
(Together with areas of extensive Rock Outcropping)

Rs C - Rockaway-Rock outcrop complex	3 to 15%
Rs D - Rockaway-Rock outcrop complex	15 to 25%
Rs E - Rockaway-Rock outcrop complex	25 to 45%'.
Rv F - Rock outcrop-Rockaway caplex	steep

Source: Sussex County, NJ. 208 Water Quality Management Plan, 1979.

Table 5

SOILS WITH SEVERE DEVELOPMENT LIMITATIONS

Sussex County Soils

No Severe Development Limitations

	Slopes
Bg B - Bath very stony loam	3' to 8%
Pa C - (where mapped separately from CD) - Palmyra gravelly fine sandy loam	B to 15%
Rh C - Riverhead sandy loam	B to 25%
Sx B - Swartswood and Lackawanna vcty stony soils	3 to 8%
Wk C - Uashington very stony loam	3 to 15%

Morris County Soils

No Severe Development Limitations

Pe C - Parker-Edneyville extremely stony sandy 1 oams	3 to 15%
Rp C - Rockaway very stony sandy loam	3 to 15%

• included within figures for Pa D (see Table 11F)

Source: Sussex County, NJ. 208 Water Quality Management Plan, 1979.

Table 6
SOILS WITH HIGH WATER TABLES

Sussex County

Poor Drainage

- Al B - Albia gravelly loam
- Al c - Albia gravelly loam
- Am B - Albia extremely stonv loam
- Cl C - Chenango cobbly sandy loam
- Cm B - Chippawa extremely stony loam
- Cn B - Chippawa silt loam
- Co B - Colonie loamy fine sand
- co c - Colonie loamy fine sand
- Fr A - Fredon loam
- Fr B - Fredon loam
- Ha - Halsey loam
- Hm B - Hibernia gravelly loam
- Hn B - Hlbemla very stony loam
- Hn D - Hlbemla very stow loam
- Dt C - Otisville gravelly loamy sand
- Ra B - Raynham silt loam
- Wt c - Wurtsboro gravelly loam
- Wu B - Wurtsboro very stony loam
- Wu c - Yurtsboro very stony loam

Flood Plalns

- Ar - Alluvial land, wet
- At - Atherton loam
- Ca - Carlisle muck
- Md - Middlesburg loam
- Pv - Pompton fine sandy loam, 0 to 3% slopes
- Pw - Preakness sandy loam
- Sm - Sloan-Uayland silt loams
- Sp - Swamp
- Wa - Wallkill silt loam

Wetlands

- Lv - Livingston silty clay loam
- LY - Lyons silt loam
- Lz - Lyons very stony silt loam
- Nh - Norwich silt loam
- No - Norwich very stony silt loam
- Uo - Whitman extremely stonv sandy loam

Morris County

Poor Drainage

- Cc B - Callfon very stony loam
- Hb C - Hibemla stony loam
- Hl D - Hlbemla very stony loam
- Ot C - Otisville gravelly loamy sand
- Rg A - Ridgebury very stony loam
- Rl B - Rldgebury extremely stony loam

Flood Plains

- Ad - Adrian muck
- Ae - Alluvial land
- Am - Alluvial land, wet
- Cm - Carlisle muck
- Mu - Cluck. shallow-over loam
- Pv A - Preakncss sandy loam, 0 to 4% slopes

Wetlands

- Wm - Whitman very stony loam

Source: Sussex County, NJ. 208 Water Quality Management Plan, 1979.

D. GROUNDWATER

Groundwater is defined as water at or below that level in the zone of stratification where all rock openings are filled with water under atmospheric pressure or greater. In the Lake Hopatcong area, groundwater occurs in the Precambrian bedrock aquifer and the Quaternary glacial stratified drift deposits.' Of the two, the stratified drift aquifers are significantly more productive than the Precambrian bedrock aquifer (Miller, 1974; Gill and Vecchioli, 1965).

A fault zone which lies within the main basin of Lake Hopatcong (Young, 1971) serves as a hydrologic connection between the lake and the aquifer. During drought periods the lake acts to recharge the aquifer, but under normal conditions groundwater infiltration to the lake occurs (PAS, 1983).

Recharge via precipitation of the stratified drift aquifer which underlies much of the watershed is conservatively estimated to be $1.96 \times 10^{2} m^{3} km^{-2} day^{-1}$ during years of average rainfall (NJDEP, 1974). Recent studies have revealed that this recharge value may underestimate actual rates by as much as two-fold (Posten, in press). However, the NJDEP value is utilized in this study as the best aquifer recharge rate currently available. Using this value, gross annual aquifer recharge is $3.92 \times 10^{7} m^{3} yr^{-1}$ for the entire drainage basin. However, due to consumptive losses, the net annual recharge is $2.67 \times 10^{7} m^{3} yr^{-1}$.

E. LAND USE AND TYPE

Land use in the Lake Hopatcong watershed was identified on the basis of aerial photographs and zoning maps. Six land use categories were used to characterize the basin (Table 7). Watershed sub-basins were identified by use of topographic maps (Figure 1). Their area and the areas of specific land use within each of the 36 sub-basins are listed in Table 8.

The majority of the watershed is forested (70.7%). Much of this land is in the northern section of the watershed. High density and low density residential land use accounts for 24.7% and 1.2% of the watershed, respectively. The majority of urbanized land occurs along the southern, southeastern and southwestern shorelines. In seventeen of the sub-basins, over 50% of the available area has been developed in the form of high density and low density residential land use. These basins (Table 9) are associated with the major residential communities. In most of these basins the density of housing is the greatest along the lake's shoreline.

Commercial land use accounts for an additional 2.6% of the basin's total area. Most of this development is confined to the major traffic corridors which intersect the basin. The majority of the commercial properties are associated with marinas, convenience stores, or service related businesses, many of which cater to tourist trade. One industry is operating in the basin. and is a quarry and asphalt manufacturing operation occupying approximately 11 ha most of which is in subwatershed number 10. The area associated with this land use has been included in the open, non-designated/disturbed category listed in Table 7. No significant acreage is utilized as farmland. This is probably due to the poor soils and steep slopes which predominate the majority of the watershed.

Table 7

DEFINITION OF LAND USE CATEGORIES

Category	Land Use
High Density Residential	One or more housing units/acre or 2.5 or more units/hectare.
Low Density Residential	Less than one housing unit/acre or less than 2.5 units/hectare.
Commercial	Business, industry, airports, and parking lots; land use in which the majority of the area is impervious.
Forested	Areas covered by an appreciable tree canopy*
Open Non-Designated/Covered	Vacant lots, parks, large lawn areas; land use which has vegetative cover but no appreciable tree canopy.
Open Non-Designated/Disturbed	Landfills and construction sites, areas of barren, undeveloped land characterized by exposed soils, lacking substantial vegetative cover.

Table 8

WATERSHED AND SUB-BASIN LAND USE ANALYSIS

Area of Land Use Within Basin

Basin No.	Area (ha)	Residential High Density	Residential Low Density	Commercial	Open Covered	Open Distrubed	Forested
1	853.1	16.6		6.5			830.0
2	769.7	8.1		33.6			728.0
3	69.6	45.1	5.9				18.6
4	266.3	17.1	1.1				248.1
5	233.1	24.7		5.3	5.7		233.1
6	213.3	44.5	8.1	8.9			151.8
7	106.4	78.1		7.7			20.6
8	356.1	27.5					328.6
9	175.2	8.5		9.3		2.0	155.4
10	111.7	10.9				10.9	89.9
11	168.4	42.9					125.5
12	90.2	60.3		1.2			28.7
13	128.3	25.5					102.8
14	176.9	25.5					151.4
15	105.2	33.2					72.0
16	183.3	87.8					95.5
17	45.3	37.4		0.8			10.1
18	15.0		13.8				1.2
19	12.1	4.4					7.7
20	142.0	67.1		8.1			66.8
21	20.2	14.6		2.8			2.8
22	161.1	43.3		7.3			110.5
23	54.2	25.1	4.9	0.8			23.4
24	37.2	24.3	6.5	2.0	2.0		2.4
25	22.7	11.3					11.4
26	30.4	15.8					14.6
27	169.6	132.3		7.7	6.1		23.5
28	56.7	44.1		5.7	2.0		4.9
29	76.5	59.1		3.2	5.7		8.5
30	15.0	13.0					2.0
31	33.2	12.6	6.9	2.0			11.7
32	117.4	29.1	2.5	8.1	0.8		76.9
33	148.1	62.3		6.9			78.9

Table 8 (continued)

Area of Land Use Within Rasin

Basin No.	Area (ha)	Residential		Commercial	Open		Forested
		High Density	Low Density		Covered	Distrubed	
34	93.9	77.7		2.8			13.4
35	198.3	132.3		10.1			55.9
36	27.1		13.0	4.0	2.8		7.3
TOTAL	5482.7	1354.7	67.1	144.8	25.1	12.9	3878.2

Table 9

SUB-BASINS WITH GREATER THAN 50% OF AREA DEVELOPED AS URBAN LAND USE

Basin No.	Location	Area (ha)	% Developed as Urban Land Use: High Density Residential	Low Density Residential	Commercial
3	West Shore Lake Shawnee	69.6	64.8	8.5	
7	Woodport East	106.4	73.4		7.2
12	Prospect Point	90.2	66.9		1.3
17	Sperry Springs	45.3	82.6		1.8
18	Raccoon Island	15.0		92.0	
20	Espanonq/Brady Park	142.0	47.3		17.9
23	David Cove/Elba Point	54.2	46.3	9.0	1.5
24	River Styx-North	37.2	65.3	17.5	5.4
26	Crescent Cove	30.4	52.0		
27	Hopatcong	169.6	78.0		4.5
29	Hopatcong/Ingram Cove	76.5	77.3		4.2
30	Point Pleasant	15.0	86.7		
31	Great Cove	33.2	38.0	20.8	6.0
34	King Cove	93.9	82.7		3.0
35	Landing	198.3	66.7		5.1
36	Landing	27.1	48.0		14.8

SECTION IV

DEMOGRAPHIC AND SOCIOECONOMIC ASPECTS

A. MAJOR TOWNS AND POPULATION CENTERS

Hopatcong Borough, Jefferson Township, Roxbury Township, Mount Arlington Borough, and Sparta Township are the major towns located within the lake's watershed. There are approximatey 34 small lake communities or population centers encompassed by these major towns (Table 10).

Table 10

MAJOR COMMUNITY CENTERS

<u>Jefferson Township</u>

Lake Winona
Woodport South
Woodport North
Lake Shawnee
Lake Forest
Tierney's Place
Prospect Point
Brady Park
Waterways
East Shores
Nolan's Point
Holiday Hills
Felter Place
Espanong

<u>Roxbury Township</u>

Landing
Silver Springs
King Cove

<u>Hopatcong Borough</u>

Woodcliff
Henderson Bay
Byram Cove
Sperry Springs
Bonaparte Landing
Elba Point
Hopatcong Hills
Pickerel Point
Ingram Cove
Point Pleasant
The Gardens
River Styx
Wildwood Shores
Knollwood

<u>Mount Arlington Borough</u>

Bertrand Island
Van Every Cove
Great Cove

B. DEMOGRAPHICS

The permanent resident population of the Lake Hopatcong watershed is 55,073 (U.S. Dept. *Commerce, 1980)* (Table 11). From 1970 to 1980 the average population increase in the major towns was 22.8%, but Hopatcong Borough experienced 71.6% growth. The total number of permanent housing units in the region is 19,926, an increase of 7,964 dwellings since 1970 (U.S. Dept. of Commerce, 1980), with the majority of residences being one family dwellings (Table 12). In the lakeside communities, the conversion of seasonal dwellings to year-round houses and new construction are responsible for the observed increases. Subsequently, cottage conversion has decreased the population size of seasonal residents. The overall result of this growth has been a continuous increase in population density from 1950 to present (Table 13), with some areas now reaching maximum development capacity (Levins and Moscowitz, 1977). Population estimates for the year 2000, project a steady increase in population of the area to approximately 20% over the currently observed figures (N.J. Dept. Labor and Industry, 1979). Many of the new housing units forecast for the region are expected to be garden apartments, town houses and other kinds of higher density housing. High density developments of this nature will not only increase the recreational demands placed on the lake, but accelerate the eutrophying process. This necessitates the development of a sound lake and watershed management plan.

Table 11

1980 CENSUS INFORMATION FOR MAJOR POPULATION CENTERS
ADJACENT TO LAKE HOPATCONG

Town	County	1960	1970	% Change 1960-1970	1980	% Change 1970-1980	White	Black	Other	Spanish	1960	1970	% Change 1960-1970	1980	% Change 1970-1980
Hopatcong	Sussex	3,391	9,052	167	15,531	71.6	15,139	169	223	454	1,019	4,456	337	6,081	36.5
Roxbury	Morris	9,983	15,754	57.8	18,878	lg.8	18,362	119	397	317	2,774	4,688	69.0	5,938	26.7
Mt. Arlington	Morris	1,246	3,590	188	4,251	18.4	4,148	22	81	119	355	1,389	291	1,667	20.0
Jefferson	Morris	6,884	14,122	105	16,413	16.2	16,266	23	124	220	2,042	5,429	166	6,240	14.9

SOURCES: 1980 Census of Population and Housing
U.S. Department of Commerce, Bureau of the Census PH CEO-V-32.

Population Characteristics in New Jersey
Department of Conservation and Economic Development.

Table 12

NUMBER OF SEASONAL DWELLING UNITS: LAKE HOPATCONG REGION*

	Hopatcong	Jefferson	Mt. Arlington	Roxbury	Total
1960	2,372[a]	1,812[b]	452[c]	1,164[d]	5,800
1970	1,604[e]	1,012[f]	269[f]	114[f]	3,000
1980	710[g]	770[h]	257[i]	109[g]	1,846

(a) 1965 Master Plan, Preliminary Report No. 1, Physical Characteristics and Population, Hopatcong Borough Planning Board.

(b) Master Plan of Jefferson Township, Jefferson Township Planning Board, 1962.

(c) Master Plan of Mt. Arlington, Mt. Arlington Planning Board, 1958 and projected to 1960.

(d) Levin, M.R. and M.S. Moskowitz, 1977.

(e) William Niesen, Economic Profile, Hopatcong Borough Planning Board, 1973.

(f) U.S. Census of Housing, 1970.

(g) U.S. Census of Housing, 1980.

(h) Elam and Popoff, Draft Wastewater Faciliites Plan, Townshio of Jefferson.

(i) Estimated from past census records.

*Modified from: Levin, M.R. and M.S. Moskowitz. 1977. Planing for an Inland Lake: Alternatives for Lake Hopatcong. Lake Hopatcong Regional Planning Board.

Table 13

POPULATION DENSITY PER SQUARE MILE, 1950-1980: LAKE HOPATCONG REGION

	Area in Square Miles	Populus/Square Mile 1950	1960	1970	1980
Hopatcong	10.80	108.6	314.0	838.2	1,438.1
Jefferson	44.30	61.9	155.4	318.8 .	370.5
Mt. Arlington	2.70	236.7	461.5	1,329.6	1,574.4
Roxbury	21.00	171.8	475.4	750.2	899.0

C. SOCIOECONOMICS

Income data for the Lake Hopatcong watershed indicates that the median family income for the area is approximately $23,500 (U.S. Dept. Commerce, 1980). Most of the work force is employed in skilled or professional positions.

Within the watershed, there are numerous service related business, such as restaurants, marinas, and convenience stores which cater to, and rely upon seasonal and tourist trade. The major industries within reasonable commuting distance of the lake are presented in Table 14.

Table 14

MAJOR INDUSTRIES AND BUSINESSES WITHIN REASONABLE
COMMUTING DISTANCE OF LAKE HOPATCONG
SUSSEX COUNTY

Company	Number of Employees	Product or Process
Accurate Forming Division Tyco Laboratories, Inc.	205	Fabricated metal products
Aerosystems Technology	169	Manufacturing
Air Filters, Inc.	75	Manufacturing
Americana Resort Hotel	600	Resort Hotel
Ames Rubber Corporation	625	Rubber products
Atlantic Service Company	51	Manufacturing
Challenge Industries, Inc.	67	Fabricated metal products
Dynapac Manufacturing, Inc.	374	Machinery
Flora Fashions, Inc.	66	Apparel
General Photo Products	54	Manufacturing
Hidden Valley	145	Ski area, recreation
Highlands Workshop/Easter Seal Society	77	Services
Ja-Bar Silicone Corporation	55	Rubber and/or plastic products
Jersey Central Power & Light Company	64	Public utility
Limestone Products Corporation	136	Mining and quarrying
Mack Wayne Plastics Company	180	Plastics
Metaltec Corporation	126	Fabricated metal products
Midlantic National Bank/S&M	113	Bank
Morley Shirt Company	340	Shirt company, apparel
The National Bank of Sussex County	81	Bank
National Community Bank	79	Bank

Table 14 (Continued)

Company	Number of Employees	Product or Process
Newco, Inc.	63	Manufacturing
New Jersey Herald	100	Printing, newspaper publishing
New Jersey Zinc Company	87	Mining and quarrying
Newton Garment Company, Inc.	52	Apparel
Plastoid Corporation	250	Manufacturing
Playboy Resort and Country Club	600	Resort hotel
Royal Business Forms	60	Printing
Schering-Plough	97	Chemical products
Selected Risks Insurance Company	674	Insurance company
United Foam Corporation	57	Chemical products
United Telephone Company New Jersey	200	Public utility
U.S. Mineral Products Company	136	Stone products
Vernon Valley/Great Gorge Ski Area	700	Ski area, recreation
Newton Memorial Hospital	575	Hospital
Tri-County Asphalt Company	30	Quarry

*Source: Industrial Directory Sussex County, 1981.

Table 14 (Continued)

MORRIS COUNTY

Company	Number of Employees	Product or Process
Allied Chemical Corporation (2 locations)	2,800	Chemical manufacturing, research and development
Automatic Switch Company	1,150	Electrical control equipment
B.A.S.F. Wyandotte Corporation	757	Corporate headquarters
Bell Telephone Laboratories (2 locations)	4,200	Communications research and development
Clay Adams Laboratory Systems	397	Surgical and Laboratory instruments
Crum & Forster Insurance Company	1,100	Corporate headquarters
Exxon Research & Engineering Company	1,200	Petro-chemical research and Engineering Services
Firemen's Fund	900	Corporate headquarters
General Public Utilities Corporation	460	Corporate headquarters
Interpace Corporation (2 locations)	530	Corporate headquarters concrete products manufacturing
Jersey Central Power & Light Company	3,534	Corporate headquarters
Kueffell & Esser Company (2 locations)	553	Corporate headquarters
The Mennen Company	648	Cosmetics and toiletries
Nabisco, Inc.	1,000	Corporate headquarters
Picatinny Arsenal	6,000	R&D - weapons command
Rowe International, Inc.	480	Vending machine and record manufacturing

Table 14 (Continued)

Company	Number of Employees	Product or Process
Sandoz, Inc.	1,367	Proprietary pharmaceuticals, manufacturing, research and development
Thatcher Glass Manufacturing Company	862	Glass bottles
Varityper Division	893	Office machinery and systems
Warner-Lambert Pharmaceutical Company	2,169	Ethical pharmaceuticals, manufacturing, research and development

*Source: Elam & Popoff, 1981.

D. RELATIONSHIP OF LAKE TO THE ECONOMY OF THE AREA

The majority of commerce in the Lake Hopatcong watershed is service related. These businesses derive much of their annual revenue in the summer, and their livelihood is directly connected to the condition of the lake. Marinas, restaurants, and motels/inns are representative examples. Decreased lake water quality will ultimately affect such businesses. Poor water quality would lead to the decreased recreational attractiveness of the lake and the loss of summer tourist trade. Statistics indicate that the majority of visitors to Hopatcong State Park are non-residents who have travelled to the area expressly for water-related recreation (Levin and Moscowitz, 1977). Maintenance of good water quality will insure the return of such tourists, and help promote business. Other benefits derived from improvement in water quality are related to recreational use by residents of the lake area as well as tourists. This aspect is discussed in detail in Section V.

Currently, aquatic macrophytes occur throughout the shallow (littoral) zone of the lake. In some areas weed beds are dense enough to impair the passage of power boats. Some parts of the lake experience phytoplankton blooms which persist throughout the summer and into fall. Such blooms are aesthetically displeasing, form slimy surface scums which discourage swimming, and may even pose a health hazard (Lundin, personal communication, 1982).

Large phytoplankton blooms and nuisance densities of aquatic weeds can also contribute to the seasonal decrease of oxygen in the deep sections of the lake due to their decomposition. This results in anoxic conditions in the hypolimnion of the lake. Lack of oxygen in these deep cold water sections of the lake prevents the establishment of a healthy cold water fishery and detracts from the recreational potential of the lake.

These factors detract from the recreational attributes of the lake. As the quality of recreation decreases, so will the drawing power of the lake. Although this may be a slow process, eventually it will effect the economic base of the area. This predicament is not necessarily unique to Lake Hopatcong, however due to the size, the history, and the proximity of the lake to the metropolitan area, the economic consequences of the lake's demise are substantial. Although the lake is much more than dollars, cents and ratables, the importance and intrinsic nature of the lake in the economic base of the watershed cannot be overlooked. Rather, it should serve as an additional impetus to initiate the restoration of this valuable recreational resource.